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Airborne Electronic Warfare: Issues for the 107th Congress

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Airborne Electronic Warfare: Issues for the 107th Congress

Summary

Electronic warfare (EW) has been an important component of military air operations since the earliest days of radar. Radar, EW, and stealth techniques have evolved over time as engineers, scientists, and tacticians have struggled to create the most survivable and effective air force possible.

Several recent events suggest that airborne EW merits congressional attention. Operation Allied Force, the 1999 NATO operation in Yugoslavia, appears to have marked an important watershed in the debate over current and future U.S. airborne EW. It appears that every air strike on Serbian targets was protected by radar jamming and/or suppression of enemy air defense (SEAD) aircraft. Electronic countermeasures self protection systems, such as towed radar decoys, were credited with saving numerous U.S. aircraft that had been targeted by Serbian surface-to-air missiles (SAMs).

The Department of Defense is engaged in numerous activities – such as research and development (R&D) programs, procurement programs, training, experimentation – that are designed to improve various electronic attack (EA), ECM, and SEAD capabilities both in the near and long term. These activities often cut across bureaucratic boundaries and defy easy categorization and oversight, which makes it difficult to determine and assess DoD-wide EW priorities. Often, it appears that DoD has no single, coherent plan coordinating all these efforts or setting priorities.

The Clinton Administration's DoD budget request for FY2001 was the 106th Congress' first opportunity to exercise oversight of EW and SEAD programs in the post-Kosovo era. Congressional appropriations and authorization conferees often matched or exceeded DoD's request for EW and SEAD programs to ensure the survivability of numerous aircraft and to increase the military's ability to suppress or destroy enemy air defenses. Congress also disagreed with DoD plans, and reduced or constrained some programs accordingly.

As part of its FY2002 budget oversight responsibilities, Congress can strongly influence DoD's EW force structure, aircraft survivability and air campaign effectiveness. Some issues Congress may consider include: 1) the overall level of DoD's electronic warfare spending, and its spending priorities within EW; 2) how DoD can wring the most warfighting capability out of its EA-6B force, which will be DoD's only radar jamming aircraft until 2010 or later; 3) why the Navy and Air Force are pursuing distinctive paths in addressing tomorrow's SEAD challenges, and whether the country is best served by pursuing both approaches; 4) why DoD and Congress appear to have distinct perspectives on the need to upgrade or replace key electronic countermeasures such as aircraft radar warning receivers.

Contents

List of Figures

Airborne Electronic Warfare: Issues for the 107th Congress

Introduction

Issues for Congress

Defense analysts generally regard enhancing aircraft survivability as a fundamental way to improve the overall effectiveness of the air campaign. Yet there are numerous means and methods for improving aircraft survivability, all with various strengths and weaknesses, risks and opportunities.[1] Airborne electronic warfare (EW), especially when coupled with stealth or low observable (LO) technology, appears to be one of the most effective techniques for increasing aircraft and aircrew survivability in hostile environments.

A number of recent events suggest that airborne EW merits congressional attention. Military planners and others note that wise choices in the acquisition, training and employment of EW systems will enable all facets of the air campaign, including reconnaissance, surveillance, and target acquisition (RSTA), strike operations, air superiority operations, close air support (CAS), and airlift. It is argued, on the other hand, that poor EW decisions could unnecessarily endanger U.S. aircraft and impede effective air operations.

A number of ongoing studies and processes within the Department of Defense (DoD) – such as the Quadrennial Defense Review (QDR) and the Electronic Attack Analysis of Alternatives (EA AOA) – are directly or indirectly grappling with decisions on DoD's near and mid term EW force structure. As part of its FY2002 budget oversight responsibilities, Congress can strongly influence DoD's EW force structure, aircraft survivability, and air campaign effectiveness. Some issues Congress may consider include:

- The overall level of DoD's electronic warfare spending, and its spending priorities within EW.
- How DoD can wring the most warfighting capability out of its EA-6B force, which will be DoD's only radar jamming aircraft until 2010 or later.

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[1]Aircraft and aircrew survivability can be increased, for instance, by changing the aircraft's characteristics (e.g. more armor, greater speed, better radar, incorporating stealth technology, or longer-range weapons). Training and exercises can also increase survivability. Operational and organizational innovation (e.g. using aircraft as "hunter killer teams" or passing information from long-range sensors to a fighter aircraft) can also increase survivability.

- Why the Navy and Air Force are pursuing distinctive paths to solving tomorrow's SEAD challenges, and whether the country is best served by pursuing both approaches.
- Why DoD and the Congress appear to have distinct perspectives on the need to upgrade or replace key electronic countermeasures such as aircraft radar warning receivers.

There are also other near term and longer term issues Congress may wish to consider. They are described in the conclusion of this report.

EW Definition and Paper Focus

The Department of Defense defines electronic warfare as "Any military action involving the use of electromagnetic and directed energy to control the electromagnetic spectrum or to attack the enemy....The three major subdivisions within electronic warfare are: electronic attack, electronic protection, and electronic warfare support."[2] Electronic warfare support can be considered the foundation of EW. This activity includes "listening" to an enemy's radars and communications to determine what frequencies and wavelengths he is using, so that others can better attack or protect against them. Electronic attack activities include jamming or deceiving an enemy's radar or radio communications, oftentimes by exploiting information collected by electronic warfare support assets. Electronic protection (or electronic countermeasures, (ECM)) also jams or deceives an adversary's use of the electromagnetic spectrum. ECM are usually used in the "end game," when an enemy missile, for example, has locked onto an aircraft and is homing in for a kill.

While not a subset of EW *per se*, the suppression of enemy air defenses (SEAD) is an important mission area that exploits EW techniques, technologies and platforms. DoD defines SEAD as "That activity which neutralizes, destroys, or temporarily degrades surface-based enemy air defenses by destructive and/or disruptive means."[3] In addition to exploiting EW techniques, SEAD platforms also use bombs and missiles to attack enemy air defenses.

The three EW sub-elements and SEAD are mutually supporting and are intimately linked. For example, DoD's only active radar jamming aircraft – the EA-6B Prowler – employs EW self protection systems. The Prowler also contributes to SEAD by jamming radar signals and by firing the High Speed Anti-Radiation (HARM) missile. Finally, the EA-6B depends on electronic warfare support information to effectively do its job. The F-16CJ (also known as the Block 50), DoD's primary SEAD aircraft, also shoots the HARM missile. The F-16CJ uses advanced ECM assets to protect itself from attack. Like the EA-6B, the F-16CJ exploits information about enemy electronic activity collected by its own sensors, or electronic warfare support platforms.

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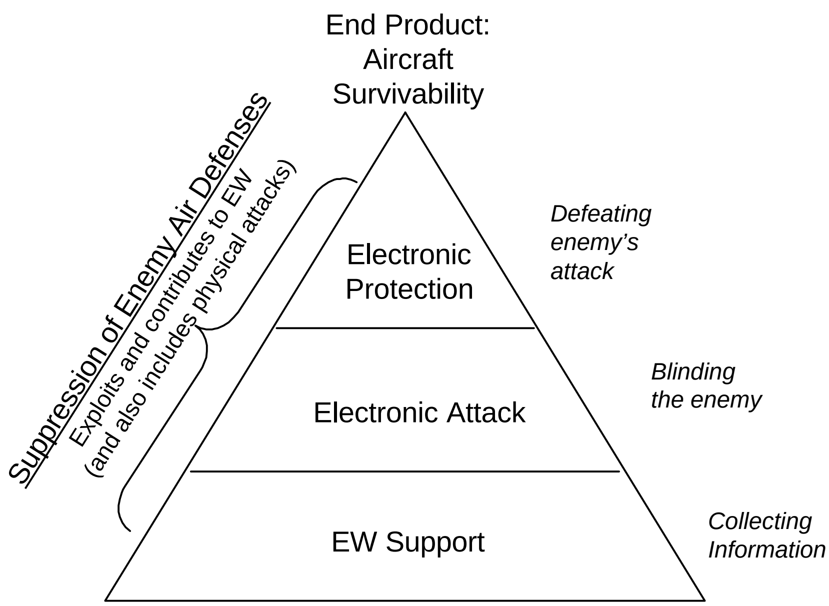
[2] JCS Pub. 1-02: DoD Dictionary of Military and Associated Terms. U.S. Department of Defense. http://www.dtic.mil/doctrine/jel/doddict/

[3] *Ibid*

This report will focus on electronic attack, SEAD and electronic countermeasures (ECM)/self-protection. Electronic warfare support issues, may be addressed in subsequent CRS studies. References will be made to electronic warfare support throughout this report as needed.

Figure 1: Illustrative EW Pyramid



Brief Background

Electronic warfare has been an important component of military air operations since the earliest days of radar. Radar, EW, and stealth techniques have evolved over time as engineers, scientists, and tacticians have struggled to create the most survivable and effective air forces possible.

During World War II, for instance, ground-based early warning radars were used early in the conflict to detect attacking aircraft at long ranges, to direct fighters to intercept them, and to warn anti-aircraft artillery (AAA) batteries of imminent attack. These ground-based radars significantly increased the success of air defenses. The attrition of attacking aircraft rose accordingly. To negate or degrade ground-based radars, the Allies and Germany quickly developed a number of countermeasures that are still employed today. Chaff (strips of metal that reflect radar emissions) was developed and used by both the Allies and Germany to confuse or obscure early warning radars. The Allies also developed radar jamming. Germany used unmanned systems (cruise and ballistic missiles) to penetrate England's air defenses. And the Allies modified their aerial tactics to reduce the amount of time that aircraft spent in enemy radar coverage.

Just as countermeasures were developed to combat radar, countermeasures were developed to counter the countermeasures. For example, Germany began using radar frequencies that were unaffected by Allied chaff. They also developed new techniques such as intercepting aircraft radar navigation transmissions, and identifying aircraft by

the unique radar return generated by the aircraft's propeller. Toward the end of the war, ECM had reduced some of the advantages that radar conferred upon air defenses. U.S. bombers employing onboard ECM during raids on Germany suffered attrition rates 25 percent less than bombers without onboard ECM.[4]

In the post World War II period, much research focused on using radar to guide surface-to-air missiles (SAMs) and AAA. Rather than just warn the missile or artillery battery of the attacking aircraft's approach, radar now provided precise information to guide the missile or artillery shell to its target. In response to radar-guided SAMs, the United States tried to increase aircraft survivability in a number of ways. Some aircraft, such as the U-2, flew very high. Others (such as the SR-71) flew very high and very fast. Still others (such as the F-111) flew very fast and at low altitudes. Many, if not most aircraft also carried electronic countermeasures.

The effectiveness of radar controlled air defenses grew, as they became more redundant and better integrated. Therefore, the United States developed many techniques to enhance aircraft survivability against systems such as North Vietnam's quadruple-layered, integrated air defenses. This era spawned, for example, the development of the F-105 suppression of enemy air defense (SEAD) aircraft, anti-radiation missiles, and airborne jamming platforms such as the EA-6B Prowler and EF-111 Raven. Also, the United States began flying aircraft in large "strike packages," where only 20-40 percent of the aircraft were "bomb droppers." Sixty to 80 percent of the escorting aircraft were employed to ensure the bombers' survivability, either through jamming, decoys, SEAD or other means.[5]

The growing reach of SAMs (e.g. the Russian built SA-5 has a range of 186 miles and a maximum altitude of 23 miles)[6] and improvements to ground based radars spawned new approaches to improving aircraft survivability. By using new materials, and designs to reduce heat emanations and to deflect or absorb radar signals, aircraft such as the F-117 Night Hawk significantly reduced the probability of detection and tracking by adversaries. As in the past however, potential adversaries have noted this advancement and are pursuing counters to "stealth" technologies. The downing of an F-117 Night Hawk in the 1999 conflict in Yugoslavia (Operation Allied Force) by a Serbian SAM illustrates that the struggle for control of the electromagnetic spectrum is an ongoing endeavor for US air forces.

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[4]Momyer. William. *Airpower in Three Wars*. U.S. Department of the Air Force. Washington, DC, 1978. p.126.

[5]Grant, Rebecca. *The Radar Game*. IRIS Independent Research. Arlington, VA. 1998. p. 19.

[6]*Jane's Strategic Weapons Systems, 1997*. Jane's Publishing Group. London.

Recent Activities

Kosovo: EW Successes and Shortfalls.

Operation Allied Force may be an important watershed in the debate over current and future U.S. airborne EW. It appears that every air strike on Serbian targets was protected by radar jamming and/or SEAD aircraft.[7] ECM self protection systems such as towed radar decoys were credited with saving numerous U.S. aircraft that had been targeted by Serbian SAMs. General Wesley Clark, the operation's military leader described how critical a role EW played in the allies' success. He testified that "We couldn't have fought this war successfully without the EA-6B contribution. We really need the electronic warfare capacity that we have there."[8] The value of the F-16CJ SEAD aircraft was also widely touted.[9] The table below suggests the impact of EW and SEAD on NATO aircraft survivability during the Kosovo campaign.

Duration of Conflict (Days)	78
NATO Aircraft	900
Sorties Flown	38,000
SAMs fired at NATO Aircraft	700
NATO Aircraft Shot Down	2

By using this metric, one can assert that DoD's EW and SEAD efforts effectively protected U.S. aircraft from Serbia's integrated air defenses. Yet, despite the low number of NATO aircraft destroyed during Operation Allied Force, concerns have been raised over a number of EW and SEAD issues.

In the area of electronic attack, the main concern raised by the Kosovo conflict is that DoD currently has too few jamming aircraft in its inventory to support more than one conflict simultaneously. Although Operation Allied Force was considered by many to be a small scale contingency, "U.S. systems such as RC-135 Rivet Joint electronic intelligence aircraft and EA-6B tactical airborne electronic warfare aircraft were employed in numbers roughly equivalent to those anticipated for a major theater war, and even then were heavily tasked."[10] Further, the number of aircraft that could

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[7]For a more complete discussion of EW in Kosovo, see CRS Report RL30639, *Electronic Warfare: EA-6B Aircraft Modernization and Related Issues for Congress*, p. 15-23.

[8]General Wesley Clark, SACEUR, Testimony to Senate Armed Services Committee. Washington, DC. July 1, 1999.

[9]Kozaryn, Linda. Air Chief's Lesson: Go for Snake's Head First. *American Forces Press Service*. October 1999. and Moniz, Dave. Eye-to-Eye with a New Kind of War. *Christian Science Monitor*. March 23, 2000:1. and Grant, Rebecca. Airpower Made it Work. *Air Force Magazine*. November 1999. p.34.

[10]Joint Statement on the Kosovo After Action Review. Office of the Assistant Secretary of (continued...)

be fielded at any one time may have been unnecessarily decreased by several operations and maintenance shortfalls – such as a shortage of spare parts and too few aircraft trainers. Also, the effectiveness of jamming aircraft may have been degraded by their lack of key technologies such as night vision devices, and advanced communications. Finally, experience in Operation Allied Force suggests that the electronic attack community would benefit from additional training and experience in supporting low-observable aircraft.[11]

There are 235 F-16CJs in the total active inventory, and this number appears to have been sufficient to adequately pursue the SEAD mission in Kosovo. However, Operation Allied Force did suggest some numerical shortfalls that may have hindered SEAD operations. According to the commander of the Air Force's 20th Fighter Wing, the lack of HARM Targeting System (HTS) pods (a key system on the F-16CJ) in Kosovo may have reduced the Air Force's ability to generate SEAD sorties. "In Allied Force, there were more F-16 aircraft capable of carrying the pod than there were pods to go around." He also said that a lack of personnel also limited SEAD operations.[12]

Perhaps a greater SEAD concern emanating from Kosovo was the great difficulty U.S. forces had detecting, tracking, and destroying Serbian SAMs that minimized their radar emissions or used "shoot and scoot" tactics[13]. Part of the challenge is that the primary SEAD weapon, the HARM, quickly loses its guidance once an adversary turns off his radar; even for a short period of time. A compounding problem is that the targeting cycle for mobile SAM sites takes too long. According to a veteran Air Force General:

> One damning shortfall, is it takes a matter of days – perhaps longer than it did during the Persian Gulf war – to locate the emissions from Yugoslav radars controlling antiaircraft weapons, and get that information to aircrews flying the bombing missions. I'd like to see a (radar) signal come up and 20 seconds later a bomb going in on the air defense site. That's the way we ought to be operating. I believe the response time has gotten longer, not shorter as you would have thought...."[14]

Secretary of Defense Cohen and Chairman of the Joint Chiefs of Staff Gen. Shelton stated in their Kosovo After Action report that the United States must reduce the time between detecting targets and attacking them.

The difficulty of destroying Serbia SAM launchers can be derived by looking at a different set of Operation Allied Force numbers:

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[10](...continued)
Defense (Public Affairs) New Release. No. 478-99. October 14, 1999.

[11]For a more detailed discussion of Kosovo "lessons learned," see CRS Report RL30639, *Electronic Warfare: EA-6B Aircraft Modernization and Related Issues for Congress*.

[12]Tirpak, John. Dealing with Air Defenses. *Air Force Magazine*. November 1999. p. 25-29

[13] *Ibid*

[14] Fulghum, David A. NATO Unprepared for Electronic Combat. *Aviation Week & Space Technology*. May 10, 1999. p.35.

Serbian SAM Batteries	22
SEAD sorties flown	4,500[15]
SAM Batteries Destroyed	2[16]

This inability to destroy Serbia's SAM launchers is particularly worrisome because according to Secretary of Defense William Cohen and Chairman of the Joint Chiefs of Staff, Gen. Hugh Shelton,

> "...although among the most capable that the United States has faced in combat, the FRY (Federal Republic of Yugoslavia) air defense systems did not represent the state of the art. Much more capable systems are available for sale in the international arms market. In the years ahead, we may face an adversary armed with state-of-the-art systems, and we need to prepare for that possibility now."[17]

Despite these perceived shortcomings, forces involved in Operation Allied Force employed their aircraft and refined tactics in ways that may hint at future solutions to the problem of destroying elusive SAMs. For example, The Air Force paired different variants of the F-16 aircraft together to exploit their various strengths.[18] Like the HARM, the F-16CJs sensors are optimized to find and attack radiating radars. Also like the HARM, the CJ has difficulty finding and targeting the radar if the adversary is careful to limit its emissions. The F-16C/D Block 40, however, has an all weather precision strike capability and carries laser-guided bombs. By using their datalink capability, F-16CJ pilots in Kosovo passed bearing information on SAM radar sites from their HTS to Block 40 F-16s. The Block 40 aircraft were then able to launch precision-guided munitions (PGMs) at the fleeting and non-emitting targets.[19] One Operation Allied Force participant remarked:

> We did have one big success when we teamed Block 40 and Block 50 on an early warning radar in Montenegro. This particular early warning radar was a problem through most of the war. When we got a tip where it was located, we had a Block 50 F-16 go in and shoot a HARM at it. The HARM hit real close and did some damage. Then a pilot in a Block 40 used his targeting pod to drop an LGB on the site to completely destroy it."[20]

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[15]Correspondence from Lt.Gen C.W. Fulford, (USMC) Director, Joint Staff to Mr. Daniel Mulhollan, Director, Congressional Research Service. October 19, 1999.

[16]Haffa, Robert P. and Barry D. Watts. *Brittle Swords: Managing the Pentagon's Low-Density, High Demand Assets*. Northrop Grumman Corp. Washington, DC. p.9.

[17]Joint Statement on the Kosovo After Action Review. Office of the Assistant Secretary of Defense (Public Affairs) New Release. No. 478-99. October 14, 1999.

[18]This technique of pairing aircraft into "hunter killer teams" is not new. The F-16CJ's SEAD predecessor – the F-4G Wild Weasel – was also used in this way.

[19]Cook, Nick. Survival of the Smartest. *Jane's Defense Weekly*. March 1, 2000. p.22-26.

[20]Allied Force Debrief. *Code One Magazine*, October 1999. Lockheed Martin Aeronautics Corp.

This experience suggests to many observers that rapid target detection, identification, and geo location will be important to the success of future SEAD missions.

The primary topic of ECM-related conversation following Operation Allied Force, was widespread praise of towed radar decoys. Although they did not debut in

Figure 2: Key SEAD Assets

EA-6B Source: U.S. Navy

F-16CJ Source: Lockheed Martin

HARM Source: U.S. Air Force

Kosovo, towed decoys were used more pervasively in this conflict than in the past. These ECM were credited with saving several aircraft such as the B-1 bomber from Serbian SAMs. Some have described towed decoys as "...one of the key enablers of last year's bombing campaign."[21] However, there were ECM deficiencies as well as successes. The ALE-39 countermeasures dispenser, for instance, was not sufficiently reliable. The ALE-39 – which is found on EA-6B, F-14, F/A-18 and AV-8B aircraft – at times did not dispense countermeasures (flares or chaff) when it was supposed to. Conversely the dispenser also ejected countermeasures without prompting, leaving the pilot with none available when they were needed.

The ALQ-126 self protection jammer's performance was also found unsatisfactory during Kosovo. Navy and Marine Corps aircraft that used this jammer – F-14s and F/A-18s – were not allowed to fly over land where the most hostile threats were located. Only those Navy and Marine Corps aircraft protected by more modern jammers were allowed to fly these missions.[22]

Operation Allied Force flight operations also suggest that passively guided SAMs are a self-protection concern that may merit close scrutiny. Shorter range SAMs can exploit infrared (IR) or electro-optical (EO) guidance [23] to target low-flying aircraft. Because these missiles do not emanate radar signals, they are difficult to detect. When asked which surface-to-air threat concerned him most, one Marine Corps officer replied "the unobserved missile."[24] Air forces that must fly at low altitudes – such as Army helicopters and special operations forces – have been forced to focus on this threat and are seeking to develop effective countermeasures. Aircraft

[21]Cook, Nick. Survival of the Smartest. *Jane's Defense Weekly*. March 1, 2000. p.22-26.

[22]Conversation with Department of the Navy Requirements Officers, January 3, 2001.

[23]Generally speaking IR systems are "heat seeking" and EO systems use TV guidance.

[24]Conversation between the author and Marine Corps EA-6B pilot. January 3, 2001.

that don't have to fly low, often reduce this threat by flying high. Allied air forces in Kosovo were able to reduce much of the threat posed by shorter range surface-to-air systems by flying at altitudes above 15,000 feet. But, large, transport aircraft that need to deliver men and material to the theater are vulnerable to short range SAMs. It was reported that "during Operation Allied Force last year, Yugoslav anti-aircraft threats forced AMC planners to sometimes choose less efficient air routes for AMC aircraft to ensure crews' safety."[25]

Select FY2001 Congressional Action on ECM and SEAD Programs[26]

The Clinton Administration's DoD budget request for FY2001 was the 106th Congress' first opportunity to exercise oversight of ECM and SEAD programs in the post-Kosovo era. The variety of programs that affect ECM and SEAD is great, and they pervade DoD's budget at all levels: operations and maintenance, research, development, testing and evaluation, and procurement. Examined singly, these disparate EW programs may appear minor, both in terms of budgetary and warfighting importance. Yet, when considered as a whole, the programs described in this section and summarized in Appendix 2 – while not a complete accounting of DoD's EW programs -- amount to approximately $859,391,000 in budget authority and constitute significant enablers of today's and tomorrow's air campaign.

Congressional appropriations and authorization conferees matched or exceeded DoD's request for ECM programs to ensure the survivability of numerous aircraft. This oversight included appropriating and authorizing $9.0 million in additional funds to procure improved ECM capabilities for the B-52, and $1.0 million more than requested to improve the antenna on the F-14's radar warning receiver. Legislators supported the BOL IR countermeasures for F-15 squadrons, appropriating $7.6 million more than requested and authorizing $26.4 million in additional funds.[27]

The BOL IR countermeasure and the ALR-69 RWR were also deemed Special Interest Items by Appropriations conferees, who wrote "The conferees expect the component commanders to give priority consideration to the following items:...F15 BOL systems...C–130 ALR–69 Radar Warning Receiver..."[28] Appropriations and Authorization conferees agreed that the F-15's ALQ-135 system was experiencing delays and technical problems, which merited a decrement of $10.4 million from the budget request.

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[25]Butler, Amy. Electronic Warfare to Remain Under Info Ops Umbrella, Official Says. *Inside the Air Force*. September 22, 2000.

[26]A detailed account of FY2001Congressional action on electronic attack programs can be found in CRS Report RL30639, *Electronic Warfare: EA-6B Aircraft Modernization and Related Issues for Congress*.

[27]The BOL dispenser is described on page 17 of this report. BOL is not an acronym, but the name of the system.

[28]106th Congress. 2nd Session. House of Representatives. Making Appropriations for the Department of Defense for the Fiscal Year ending September 30, 2001, and For Other Purposes. Report 106-754. H.R. 4576. July 17, 2000. p. 217.

Congress also supported EW research, development, test and evaluation (RDT&E) programs by appropriating increased funding of $14.7 million for the Air Force's Miniature Air-Launched Decoy (MALD), Precision Location and Identification (PLAID) and other survivability enhancements. Navy RDT&E on the Integrated Defensive Electronic Countermeasures (IDECM) program was also enhanced by an appropriation of $3 million more than requested. Appropriations conferees considered the Navy's plan to produce IDECM RFCMs to be premature, and reduced their request by almost $30 million.[29]

The 106th Congress (second session) also provided oversight of several important DoD SEAD programs. The Air Force's primary SEAD aircraft, the F-16C/J received considerable congressional attention. Appropriations conferees provided $122 million to acquire four new F-16C/Js while authorization conferees provided $51.7 million for two aircraft.

Appropriations and authorization conferees also agreed to provide $10 million in procurement funding for the acquisition of the Improved Tactical Air Launched Decoy (ITALD). This decoy was used with great success during the 1991 war with Iraq (Operation Desert Storm). Iraqi radar operators frequently mistook ITALDs for manned aircraft, and tracked them with their fire control radars. This alerted the Coalition allies of the Iraqi radar's position and allowed them to avoid or attack them.

Appropriations conferees also made available an additional $15 million for the Advanced Anti-Radiation Guided Missile (AARGM) and an additional $5 million for the Quick Bolt program. Both programs are advanced technology demonstrations designed to improve the HARM's ability to track and engage enemy radars even if they shut down emissions. Authorization conferees supported AARGM with $5 million.

Authorization conferees added $200 million in RDT&E to fund a demonstration project to explore the feasibility and effectiveness of unmanned combat aircraft. The goal of this provision was to stimulate DoD efforts in unmanned vehicles, such that "within 10 years, one-third of U.S. military operational deep strike aircraft will be unmanned..."[30] Conferees also recommended that these efforts should focus on the highest risk mission areas. "For aircraft, this mission area is defined as those early entry deep strike missions for suppression of enemy air defenses and other highest priority targets."[31]

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[29] *Ibid*. p. 168

[30] 106th Congress. 2nd U.S. House of Representatives. Report 106-945. H.R. 4205. Enactment of Provisions of H.R. 5409, the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001.Section 220, p. 720-721.

[31] *Ibid*

Overview of Recent DoD EW Activities[32]

The Department of Defense is engaged in numerous activities – such as R&D programs, procurement programs, training, and experimentation – that are designed to improve various EA, ECM and SEAD capabilities both in the near and long-term. These activities often cut across bureaucratic boundaries and defy easy categorization and oversight, which makes it difficult to determine and assess DoD-wide EW priorities. In the area of SEAD, for example, the General Accounting Office (GAO) recently reported that DoD lacks a comprehensive strategy for improving its SEAD capabilities. Because DoD has no overarching EW coordination strategy, the Service's efforts to improve EW capabilities are paramount. However, "...service level decisions are, in our view, much less likely to reflect the needed priority for closing the gap (between the services capabilities and their needs) and to be the most cost-effective solutions for the Department overall."[33]

Electronic Attack-related Activities

Perhaps the most noteworthy activity related to electronic attack is the Electronic Attack Analysis of Alternatives (AOA). The Navy is leading this joint study, which was funded by FY2001 Defense Appropriations. The AOA's mandate is to study and recommend how DoD might best field an EA capability in the 2010 time frame. This is when the EA-6B Prowler is expected to be retired.

The AOA team has divided into various integrated product teams that are focused on cost, threat, technology, and operational measures of effectiveness. As of December 2000, the AOA had received over 170 briefings from industry and had assessed at least 23 different EA platform options. As of January 2001, the AOA was conducting modeling and simulation runs on various alternatives, and expected to begin analysis of the computer output in March and April 2001. The AOA team anticipates briefing the Office of the Secretary of Defense (OSD) and Service leadership in the August 2001 time frame, and delivering their final report to OSD by their deadline of December 15, 2001. The FY2004 budget cycle will be the first opportunity to begin implementing the AOA recommendations toward a 2010 initial operating capability (IOC).

It is unlikely that the AOA will recommend a single point solution to DoD's 2010 electronic attack needs. Instead, the AOA will probably recommend multiple alternatives designed to give the services flexible and redundant capabilities.

In addition to chairing the AOA, the Navy has been engaged in several activities over the past two years designed to address electronic attack shortfalls identified in

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[32] The activities described in this and the following section do not include all DoD activities. Electronic warfare is an area in which much secret work (often called black programs, or special access programs) is probably conducted. It would be inappropriate for the Congressional Research service to report on, or for DoD sources to comment on, this work.

[33] Electronic Warfare: Comprehensive Strategy Needed for Suppressing Enemy Air Defenses. General Accounting Office. GAO-01-28. January 2001. p.3.

Kosovo. First, the EA-6B community has begun acquiring and training with night vision devices (NVDs). The entire EA-6B fleet is expected to be equipped with NVDs by the fall of 2002. Second, the Navy and Air Force have collaborated in integrating former EF-111 crews into the EA-6B fleet. Thus far, 24 USAF personnel have undergone EA-6B training. These additional pilots and electronic countermeasures officers should help address personnel shortfalls that may have slowed operational tempo during Operation Allied Force. Third, the Navy is in the process of standing up a nineteenth EA-6B squadron. This new expeditionary squadron should be fully operational some time in calendar year 2002.[34]

In the aftermath of Kosovo – where EA assets played an important role – the decision to retire the Air Force's EF-111 Raven and to give responsibility for airborne radar jamming to the Navy and Marine Corps has been questioned in the press, defense academia, and government. The Air Force has also questioned its current footing in electronic attack, and has revamped its overall policy, doctrine and budgetary positions on EW. On July 7, 2000, for instance, the Air Force's highest ranking officers held an "EW Summit."

Many of the Air Force's recent activities have been organizational changes that may greatly affect the service's electronic attack capabilities in the mid and long term. For example, the Air Force has created a new organization on the Air Staff – called XOIE[35] – to more effectively develop and coordinate operational EW requirements. This office, in turn, has developed an EW road map and action plan that will address the balance between current systems and future technologies. The Air Force has also established EW offices in its Major Commands (e.g. the Air Mobility Command, Air Combat Command, Air Force Space Command, Air Force Special Operations Command) to better rationalize EW resources and priorities across all programs.

In November 2000, Chief of Staff of the Air Force General Michael Ryan announced his new position on EW: "The USAF is committed to a support jamming capability adequate to sustain the AEF and Joint air, ground, sea and space operations across the spectrum of conflict. To fulfill AEF CONOPs, the Air Force will define adequate AF EW force structure required to meet projected AEF deployments.[36]

In addition to these organizational changes, the Air Force has also embarked on activities designed to improve, more immediately, their EA capabilities. For instance, the Air Force continues to maintain its only EA asset, the EC-130H Compass Call. The Air Force has an inventory of 14 of these communications jamming aircraft. According to the Air Force, the Compass Call "has achieved some significant

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[34]CAPT Doug Swoish. Commander VAQ Wing Pacific. EA-6B Prowler Overview Briefing. January 16, 2001.

[35]The Air Staff, that supports General Michael Ryan, Chief of Staff of the Air Force, is divided into several offices. The letters, XOIE are used to indicate where the new EW office fits in the larger bureaucracy. XOIE is found under XOI, The Director of Intelligence, Surveillance and Reconnaissance. XOI, is found under XO, the Deputy Chief of Staff for Air and Space Operations. XO reports to General Ryan.

[36]CSAF Electronic Warfare (EW) Position Statement. November 2, 2000. HQ USAF Washington, DC.

performance advances as part of several classified upgrade programs" over the past several years.[37]

The Air Force is also working on improving its ability to combine LO and EW operations. According to XOIE officials, at least two combat training exercises have been conducted at Nellis AFB in the post-Kosovo time frame which were designed to improve the integration of EA and LO platforms. Also, general officer-level coordination meetings have been initiated in the Pentagon to address EA and LO training and infrastructure needs. General Ryan has stated that "The USAF believes that a combination of EW and low observables (LO) are required to assure air superiority in the 21st century battlespace."[38]

Suppression of Enemy Air Defenses

To improve their ability to destroy enemy air defenses, the Navy is engaged in programs designed to improve the HARM missile's ability to target enemy radars that have been turned off. The Advanced Anti Radiation Guided Munition (AARGM) Advanced Technology Demonstration (ATD), for example, aims to add INS/GPS midcourse guidance and a millimeter wave (MMW) radar seeker to the HARM missile's active radar homing (ARH). The targeting information from all three sensors will be fused on-board the missile, with the goal of providing a robust targeting capability. If an enemy turns off his radar to defeat the ARH seeker, the MMW radar is designed to continue searching for the radar and guide the missile to it. AARGM is also designed to maneuver at the end of its flight to find and destroy the SAM site's highest value target, such as the missile launcher itself. The current HARM can only zero in on the SAM radar, often leaving the missile launcher intact.

The Navy is also working with the National Reconnaissance Office (NRO) on the Quick Bolt Advanced Concept Technology Demonstration (ACTD). Quick Bolt is designed to improve the AARGM's targeting capabilities by allowing the launch-aircraft to update the missile's targeting library with information that it receives from "off-board" sources (e.g. satellites). Quick Bolt is also designed to improve SEAD battle damage assessment (BDA) capabilities – a significant challenge in Kosovo. Quick Bolt will add a transmitter to the AARGM that is designed to allow it to transmit back to headquarters its exact location just prior to striking the target. This information can then be assessed to help determine the probability of destruction. The Quick Bolt ACTD is scheduled to be completed in FY2004.

Air Force planners have taken a fresh look at SEAD capabilities in the post Kosovo era. As directed by the aforementioned EW Summit, the Air Combat Command (ACC) has developed a concept of operations called "Countering Air Defenses," or CAD. This document is intended to serve as the foundation for improving the Air Force's SEAD capabilities. Air Force personnel describe CAD as the most comprehensive document of its type ever written by the Air Force.

[37] *Fact Sheet*. U.S.A.F. Legislative Liaison. Weapons systems Division. 1160 Air Force Pentagon. January 9, 2001.

[38] *Ibid*

The Air Force has also led training activities designed to improve SEAD capabilities. For instance, the USAF hosted a Joint SEAD test and evaluation at Nellis air force base in August and September 2000 designed to update and test SEAD tactics. The Air Force also annually runs Joint Expeditionary Force Exercises. The one held September 11-14, 2000 at Nellis AFB focused on improving time critical targeting capabilities; such as destroying SAMs that employ shoot-and-scoot tactics.

The Air Force is engaged in a variety of programs to improve its SEAD capabilities. Perhaps the most prominent are upgrades to the Harm Targeting System (HTS), the Advanced Targeting Pod (ATP) and the Miniature Air Launched Decoy (MALD).

Since the fielding of the original HTS, the Air Force has pursued a pre-planned product improvement program that has resulted in fielding two HTS upgrades; Revision 5 (R5) in 1996 and Revision 6 (R6) in 2000. The R-6 software/hardware modification improved the HTS' geolocation capability. HTS Revision 7 (R7) is currently funded and under development. Initial Operational Capability (IOC) is expected in FY 2006. The goal of the R7 upgrade is to further improve the HTS geolocation capability. R7 is designed to allow faster precision HARM employment and enable the targeting of JDAM (Joint Direct Attack Munition), JSOW (Joint Stand Off Weapon) and potentially other standoff precision guided munitions against fixed and mobile enemy air defense systems employing emission control tactics.[39] The dispersal of JSOW submunitions would also increase the likelihood of destroying all of a SAM battery's assets: radars, missile launchers and command and control vehicles.

The ATP is designed to give the SEAD-capable F-16CJ the same precision targeting capability as the F-16C/D models; essentially turning the F-16CJ into a true multi-mission aircraft. The exact features will probably include a high-resolution, forward-looking infrared sensor (which displays an IR image of the target to the pilot) and a laser designator for precise delivery of laser-guided munitions. The combination of the HTS R7 and ATP should give a single F-16CJ the very promising capabilities against mobile SAMs demonstrated in Kosovo (see preceding pages 7 and 8) by two different F-16 models working together.

The MALD is designed to improve both SEAD capabilities and contribute to aircraft self-protection by attracting the attention of enemy SAM radars. This small (25 inch wing span), turbo-jet powered decoy will employ a signature augmentation system (SAS) that will make it look like a much larger, manned fighter aircraft to enemy radar operators. When enemy radars or SAMs attempt to engage the MALD, real fighter aircraft will be free to attack or avoid the SAM. The MALD SEAD concept of operations (CONOPs) could include several strategies, including: 1) preemptive destruction; 2) reactive suppression; 3) diversion (as just described); or 4) saturation. A key program goal is to keep the cost of MALD below $30,000 per decoy for a 3,000 unit purchase. The Defense Advanced Research Projects Agency (DARPA) announced on January 22, 2001 that it is transferring the MALD program

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[39] *Fact Sheet*. U.S.A.F. Legislative Liaison. Weapons systems Division. 1160 Air Force Pentagon. January 9, 2001.

to the Air Force, for a possible limited procurement of 100 to 150 decoys over a three year period, starting in FY2002.[40]

Another post-Kosovo SEAD activity is DARPA's Advanced Tactical Targeting Technology (AT3) program. This program will seek to "...demonstrate a passive tactical targeting system for the lethal suppression of enemy air defenses (SEAD)."[41] The crux of the AT3 program is to widely distribute passive radar receivers throughout the battle space and to network them together. No single asset will be tasked with sensing or destroying enemy SAM systems; they all will. This program is an example of the type of SEAD technological innovation recently discussed by the General Accounting Office.[42]

The first element of the AT3 concept is advanced electronic warfare support hardware. The AT3 elements will exploit, and be composed of, Global Positioning System receivers, precision clocks, and low-cost wideband receiver/processors. Although the exact size of the AT3 hardware has not yet been determined, the program hopes to make them small enough to fit on a UAV or other "vehicles of opportunity."

The second element of AT3 is advanced networking. By linking the electronic warfare support modules together – say with Link 16[43] – every element on the network would function cooperatively. Different AT3 sensors would pick up a threat enemy radar signal from different points in time, space and frequency. DARPA hopes that by rapidly calculating the difference between when and where each receiver intercepts the threat radar signal, the AT3 network will pinpoint and disseminate the enemy's location in 10 seconds or less.

DARPA says that the biggest technical challenge to this approach is "PVTF," or the ability to synchronize position, velocity, time and frequency among all the participants in the network. Synchronizing the time difference and frequency difference of arrival for all participants in the network is both a computer processing and software challenge. The network's accuracy increases with the number of modules involved, but so does the technical complexity of PVTF.

In its most successful manifestation, DARPA hopes AT3 will make dedicated SEAD aircraft unnecessary. The AT3 network's ability to identify a target within 10 seconds could enable any shooter – such as the Army Multiple Launch Rocket System, Navy five-inch guns, or Air Force fighter or bomber aircraft – to attack non-emitting or "shoot-and-scoot" SAMs. DARPA plans to conduct flight tests in FY2002 in which it will geo-locate a radiating target in near real time.

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[40]Woods, Randy. DARPA Transferring Air Launched Decoy to Air Force. *Defense Information and Electronics Report*. January 26, 2001.

[41] http://www.darpa.mil/spo/Programs/att.htm

[42]*Electronic Warfare: Comprehensive Strategy Needed for Enemy Air Defenses*. General Accounting Office GAO-01-28. January 3, 2001. p. 11.

[43]Link 16 is a high data rate, jam resistant communications data link.

Self Protection

The services are engaged in myriad efforts to improve defenses against surface-to-air and air-to-air guided missiles. Almost every aircraft in DoD's inventory employ's systems to detect approaching missiles, generate appropriate electronic or IR techniques to jam or deceive the threat, and a system to deliver the technique. As enemy SAMs and AAMs improve, the Services are continually seeking to modify or improve these self protection systems.[44]

Some of the more prominent DoD self-protection activities include the Integrated Defense Countermeasures (IDECM) system, the Large Aircraft IR Countermeasures program (LAIRCM), the Precision Location and Identification (PLAID) upgrade to the ALR-69 radar warning receiver, and the BOL IR countermeasures dispenser.

The IDECM program is jointly run by the Navy, Air Force, and Army, and composed of three sub programs: the Radio Frequency Countermeasures (RFCM) jammer; the Common Missile Warning System (CMWS); and, the Advanced Strategic and Tactical Expendable (ASTE) program. The Navy is leading the RFCM program, which is developing the ALQ-214 radar jammer to replace the Airborne Self Protection Jammer (ASPJ) and other legacy jammers, and the ALE-55 fiber optic towed decoy, which improves upon the ALE-50 decoy. The systems are planned for employment on the F/A-18E/F, followed by the B-1B and F-15. The Army is leading IDECM's Common Missile Warning System, which is intended to alert a variety of Army, Navy, Marine Corps, and Air Force aircraft of attack by IR guided missiles. The Air Force leads ASTE. This self-propelled flare is designed to increase aircraft survivability against next generation IR and electro-optical (EO) threats.

The PLAID upgrade to the Air Force's ALR-69 radar warning receiver will be composed of "digital RWR technology and specialized receiver software algorithms for greatly improved geographical location, azimuth accuracy, and slant range measurements and determination of specific emitter identification information on detected threats."[45] These capabilities will improve combat threat identification capabilities for the aircrews on aircraft which operate the ALR-69: the F-16, C-130, C-141, and A-10 aircraft.

Large aircraft require large engines. Large engines tend to produce lots of power and heat, and generate large IR signatures. To protect these aircraft from heat seeking missiles, the Air Force is pursuing a variety of directed IR countermeasures (DIRCM).[46] The LAIRCM program, for example, is a laser-based aircraft self-

[44]Examples of other ECM upgrade efforts include: B-1 Defensive Systems Upgrade (DSUP), Improvements or upgrades to ALQ-172 jammers on B-52, MC-130E/H, AC-130U, and AC-130H.

[45]Svitak, Amy. Senate Approves Funding Boost for Air Force Radar Warning Upgrade. *Defense Information and Electronics Report*. June 30, 2000.

[46] Klass, Philip. New Lasers Enhance DIRCM Capabilities. Aviation Week & Space (continued...)

protection system designed to defeat all IR guided missiles and is intended to be more effective than traditional flare countermeasures. The Air Force believes that the most promising R&D efforts include two-color missile warning efforts and the Laser IR Flyout Experiment (LIFE), designed to be a more advanced LAIRCM follow-on system.[47] BAE Systems and Northrop Grumman recently delivered their first AAQ-25 DIRCM, which will be used on C-130 airlifters.[48]

The Air Force and Navy are both interested in using the BOL chaff and IR countermeasures dispenser. This six foot long canister is designed to very rapidly eject up to 160 small IR countermeasures that will give aircraft a "preemptive self protection" capability. The BOL is manufactured by Sweden's Celsius Technologies and is already employed on the F-14 and foreign aircraft. The F-15E is the Air Force's leading candidate for hosting the BOL dispenser.

The Way Ahead: Likely EW Priorities in FY2002

Navy and Air Force officials have indicate that their electronic warfare priorities for FY2002 will likely be very similar to those in FY2001. For the Navy, this 2001-to-2002 consistency is due to the fact that the Navy believes its EW responsibilities are clear and the challenges well understood. The Air Force's FY 2002 EA priorities will resemble those of FY 2001 more for reasons of momentum. The fundamental organizational, policy, doctrinal, and budgetary changes that the Air Force has initiated on EW are still solidifying. Thus, for example, those responsible for developing the service's FY2002 budget request were not guided by XOIE's EW Roadmap.[49] FY2003 will probably be the first Air Force budget strongly influenced by the Air Force's new position and policies on electronic attack.

Electronic Attack

The many different parties within the Navy's EA community speak with one voice on 2002 requirements. They want, in order of priority; 1) improved EA-6B readiness; 2) ICAPIII; 3) improvements to jamming capabilities; and 4) Link-16 implementation. With only 124 EA-6B aircraft in the inventory to support all DoD combat flight operations, it would appear prudent to them to keep as many of these aircraft in a ready state and at the highest level of effectiveness as possible. According to the Navy "the most significant near term challenge facing the EA-6B community is the gradual decline in aircraft readiness."[50] The EA-6B Operational Advisory Group

[46](...continued)
Technology. May 22, 2000. p. 56.

[47]*Fact Sheet*. U.S.A.F. Legislative Liaison. Weapons systems Division. 1160 Air Force Pentagon. January 9, 2001.

[48]Aerospace Daily. February 6, 2001.p. 196.

[49]Discussions with XOIE officials December 27, 2000.

[50]*EA-6B ESC Top Ten War-Fighting Requirements*. EA-6B Operational Advisory Group. (continued...)

(OAG) believes that readiness will be improved by addressing shortfalls in the Prowler supply system, including parts such as flaps, rudders, radomes, and struts. The Navy has experienced a continuous shortfall in O&M funding for ALQ-99 pod repair and refurbishment is particularly bothersome. Making sure that these pods are maintained appropriately could increase the Prowler fleet's readiness rate by 30 percent. [51]

Once the Navy ensures that the EA-6B fleet is as ready as it can be, its second priority is to improve the Prowlers' effectiveness. The best way to do that, Navy planners believe, is by implementing the ICAP III upgrade to the Prowler's ALQ-99 and USQ-113 jammers. ICAP III should improve the EA-6B's capabilities against "frequency hopping" radars, and provide better geo-location of threats. The EA-6B OAG endorses ICAP III production "at the maximum rate allowable." Two ICAP III trainers, one for Whidbey Island, WA and one for Cherry Point, NC, would help the Navy sooner realize the ICAP III's capabilities, Navy planners say.

Making additional improvements to the EA-6Bs jamming pods is the Navy's next EA priority for FY2002. A number of improvements are believed to be required to improve the Prowler's capabilities over the long term, and to enhance joint strike aircraft survivability. In order of priority, the Navy would: 1) continue funding the research and exploitation of enemy radar systems to improve EA-6B jamming techniques; 2) upgrade the EA-6B's low band transmitter to increase its frequency coverage; and 3) acquire an additional 61 USQ-113 (V)3 communications jammers so that all 124 EA-6Bs in the fleet could field this capability.[52]

The third way the Navy would improve the EA-6B's capabilities, and their fourth overall EA priority, would be to accelerate the fielding of Link 16. "As the sole provider of tactical electronic attack capability on the joint battlefield, it is imperative that the EA-6B have uninterrupted connectivity with strike and support assets," states the EA-6B OAG.

In the next year the Air Force will continue evolving its policy, organizational, and doctrinal positions on electronic attack. It will continue to participate in the EA AOA. It will continue to develop and coordinate new CONOPs like *Countering Air Defenses*. The communications jamming EC-130H Compass Call is the only line item in the Air Force's budget that legislators may have to consider. The Air Force currently has sufficient funding to upgrade 11 of its 14 EC-130H aircraft to the most capable configuration. In FY2002 it is likely that the Air Force will request funding to upgrade the remaining three aircraft. No new Air Force radar jamming platforms will emerge prior to the EA AOA recommended EA-6B follow on in the 2010 time frame.

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[50](...continued)
September 27, 2000.

[51]*Ibid*.

[52] The shortage of USQ-113 (V) 3 jammers is both an effectiveness and also a readiness issue. Currently the Navy constantly swaps the 63 USQ-113 jammers they own among the 124 Prowler airframes, which creates an unnecessary bottleneck in the system.

Suppression of Enemy Air Defenses

Two important SEAD lessons have emerged from Kosovo. First, there is a need to more quickly locate and target SAM systems. Second, there is a need to more effectively target SAM systems that limit their radar emissions. The Air Force, as part of its desire to move from today's reactive suppression of enemy air defenses to the ability to preemptively destroy enemy air defenses, the Air Force is likely to emphasize programs that will also help solve these two problems.

Perhaps the most powerful technique for shortening the SEAD targeting time line is sensor fusion. It may be that by emphasizing programs in their FY2002 budgets that fuse airborne sensor data, the Air Force and Navy may more effectively destroy future enemy air defenses. On February 5, 2001, DoD announced its new ACTDs for FY2001. One of them, called "Network-Centric Collaborative Targeting (NCCT), is an example of this sort of SEAD approach. This program will attempt to network operational ISR sensors found or platforms such as RC-135 Rivet Joint, JSTARS, AWACs, Global Hawk, Predator, U2 and the Navy's EP-3 in an attempt to significantly improve the capability to detect, identify and locate time critical targets such as enemy air defenses. These sensors have different but complementary capabilities. By networking these sensors and processing the data in a collaborative way, DoD hopes to reduce target location error and targeting time lines. The U.S. Central Command is the operational sponsor of this program, which has a planned completion date of FY2005.

Another high priority to more quickly attack enemy SAM systems is the acceleration of the fielding and integration of Link-16 on as many combat aircraft as feasible. This capability could facilitate the automated sharing of fused information among battle space participants and could significantly improve tactical command and control. Especially when coupled with a PLAID capability, Link-16 capable aircraft may more quickly pass location, cuing, and targeting information to other aircraft that may be better positioned or better armed to prosecute that attack. The acceleration of the procurement of the HTS version 7 and the Advanced Targeting Pod may also be important SEAD priorities. The Air Force eventually wants enough F-16CJs with ATPs to support all 10 AEFs.

One way to attack an enemy SAM radar that won't emit, is to trick it into emitting. The MALD and ITALD may be high Air Force and Navy priorities in FY2002, because they should be able to use these decoys to stimulate enemy integrated air defenses. Once turned on, the enemy radar will be more easily avoided or attacked. The Air Force is aiming for a MALD production run in FY2002.

The Navy's AARGM and Quick Bolt programs are other approaches to destroying enemy radar that limit their emissions, and these will likely be emphasized in the FY2002 budget cycle. The AARGM ATD is expected to be complete at the end of calendar year 2001, and will include test firings at the Navy's China Lake range in March and August. A critical juncture for the program, say industry officials, is the FY2003 budget, when the Navy must decide to commit $300 million to the program for systems development and demonstration. Industry representatives also say that the AARGM is anticipated to cost no more than the baseline HARM missile, if bought in

the 1,800 unit production desired.[53] The Quick Bolt ACTD – the U.S. European Commands top priority ACTD in FY 2000 -- is in its first phase. Navy scientists and engineers hope to integrate the Quick Bolt receiver and transmitter with AARGM to begin demonstrating improved situational awareness.

Self Protection

In terms of self protection, Navy priorities appear very focused. The F/A-18E/F is the top aviation priority, and IDECM is the top self protection priority. The Navy considers the ALQ-126 RFCM to be obsolete. During Kosovo, any Navy or Marine Corps aircraft that operated the ALQ-126 (F-14s and F/A-18s) were not allowed to fly over land, where Serbia's most threatening SAMs were located. IDECM's ALQ-214 RFCM will replace the ALQ-126 and ASPJ. IDECM's ASTE and the BOL IR countermeasures dispenser are also important to the Navy and may play an important role in FY2002 activities.

Air Force requirements officials indicate that they would like to replace many of the older self protection systems such as the ALQ-131 and ALQ-184 jamming pods, but believe that the numbers involved would require funding currently beyond what is likely available. It may be, then, that these improvements will be on the Air Force's FY2002 unfunded priority list.[54]

In addition to these legacy jamming pods, the Air Force self protection efforts will likely focus on completing the engineering, manufacturing and development (EMD) phase of the PLAID system, increasing ALE-50 production, and making progress on the ASTE program, the LAIRCM program, and long duration IR threat protection systems like the BOL dispenser.

Considerations for Congress

The previous sections provide a snapshot of DoD's activities to improve its electronic attack, SEAD and self protection capabilities, and where improvements reportedly still need to be made. During the research and study of these issues, a number of concerns related to congressional interests emerged. These concerns can be divided into two groups, those that could be addressed immediately, and those that have a longer time horizon.

The first, and over arching congressional concern may be the EW budget. Considering the importance of EW, are the services spending an appropriate amount on EW programs? Many argue that, as the United States moves toward warfighting concepts that emphasize the use of information and communications technology to make better and faster decisions on the battlefield, EW becomes increasingly

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[53]*AARGM/QB Program Summary*. Presentation by Science and Applied Technology, Inc. January 17, 2001.

[54]*Fact Sheet*. U.S.A.F. Legislative Liaison. Weapons systems Division. 1160 Air Force Pentagon. January 9, 2001.

important. Have the Services and DoD accepted this perspective, and if so, is it reflected in their spending priorities? A sub issue concerns the emphasis the Services place on electronic attack versus SEAD versus self protection. Generally speaking, the Navy's budgeting priorities suggest an emphasis on electronic attack. The Air Force's budgetary priorities suggest an emphasis on SEAD. Both services appear to put less emphasis on self protection relative to the other sub components of EW. This raises the issue of finding the best balance of EW resources..

The second immediate concern pertains to the EA-6B fleet and may be as important as any other issue raised in this paper. Can DoD wring the most warfighting effectiveness from the 124 airframe fleet as possible over the next 10 years? Kosovo clearly illustrated both the importance of these radar jamming aircraft to the success of the air campaign and, also, how thinly stretched the fleet could become. Post-Kosovo, the Navy has taken steps to increase the Prowler's combat capability, including procuring NVDs and taking steps to create a new squadron. Yet, they are still constrained to a finite number of airframes. It appears unlikely that the Navy will acquire more radar jamming airframes before 2010, and the Air Force has stated that they will develop their own radar jamming capabilities, based on the EA AOA recommendations, to be fielded in the 2010 time frame.

One approach that may generate more combat effectiveness out of the Prowler fleet would be to create a fifth Marine Corps EA-6B squadron from the current Marine Corps inventory of 20 aircraft. The Marine Corps currently divides these 20 aircraft into four squadrons of five aircraft each. All 14 Navy squadrons, as a point of comparison, are composed of four Prowlers each.

Navy requirements and operational officers say that all EA-6B squadrons are deployed on an equal basis. The Navy tries to schedule deployments so that no single squadron gets burnt out, while another rests, regroups and trains in the United States. Thus, if all squadrons are deployed equally, those containing five aircraft may get less work than those with four. It has been suggested that by reducing today's Marine Corps squadrons to four aircraft each, and creating an additional Marine Corps EA-6B squadron, the overall EA-6B fleet workload would be more equitably distributed, and the fleet more able to address its far-flung responsibilities. If maintenance or other issues make it difficult for the Marine Corps to organize their aircraft into four-plane squadrons, an alternative suggestion, coming from a recent professional journal, is to surrender this mission to the Navy.[55] The issue of which of the various schemes for best organizing the EA-6B force is most viable remains unresolved.

In addition to getting the most "bang for the buck" from the EA-6B fleet, improving DoD's capability to suppress or destroy enemy air defenses is another important consideration. Currently, the Navy and Air Force appear to have distinctive approaches to this problem. The Navy is attempting to improve its missile's ability to find non-emitting enemy radars and target them, and other high value SAM battery assets – such as the missile launcher. The Air Force, on the other hand, is attempting to improve the aircraft's ability to find the adversary, and will use less expensive

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[55] Moloko, John. Let the Navy do the Prowling. *Marine Corps Gazette*. December 2000. p. 42.

weapons, or weapons that dispense sub-munitions to attack the target. In short, the Navy is "putting the smarts" on the missile, while the Air Force is "putting the smarts" on the aircraft, or targeting pod.

More broadly speaking, the Air Force appears to favor more advanced platforms to perform tomorrow's SEAD mission than does the Navy. The Air Force proposes that the F-22 Raptor is the platform best able to achieve and maintain air superiority, both by clearing the skies of enemy fighters, and by destroying enemy air defenses.[56] Recent statements by the Chief of Staff of the Air Force and other Air Force officials on the compatibility of EW and low observable platforms, and the Air Force's need to populate Aerospace Expeditionary Forces (AEFs) with EW aircraft, suggest that the F-22 would operate with support from these assets. The Navy, implicitly, takes a more modest approach to achieving tomorrow's SEAD goals proposing to use the more conventional F/A-18E/F Super Hornet – also supported by an electronic attack aircraft – to attack enemy air defenses.

Considering the importance and difficulty of suppressing or destroying enemy air defenses, it may be that pursuing two different strategies is a prudent overall approach. But questions persist on matters of continuing congressional interest: Does achieving tomorrow's SEAD goals require relatively modest upgrades to today's platforms and munitions? Or, does the United States need significantly more advanced aircraft and targeting capabilities than it has today? Congress may wish to consider whether one of these approaches is superior to the other and whether cost savings could be achieved by pursuing only one strategy.

Another SEAD issue pertains to training. Naval aviators, for example develop and hone their jamming and SEAD skills at Fallon Naval Air Station by flying against real Russian SAM radars and other foreign military equipment. However, officials at the Naval Strike and Air Warfare Center at Fallon report that they suffer a chronic shortage of these very useful radars, not because they don't exist, but because U.S. intelligence agencies own them, but, these officials say, apparently won't lend them to Fallon.[57] This too, is an ongoing issue.

A fourth concern that Congress may wish to address in the near term is the continuing difference of opinion between Congress and DoD on the effectiveness of current radar warning receivers. Upgrading aircraft RWRs does not appear to be a high priority for DoD. Yet, Congress has expressed consistent concern that older RWRs offer inadequate protection against emerging enemy SAMs. Senate appropriators, for instance wrote:

> The Committee is concerned that many of the Defense Department's active and reserve fighter aircraft have inadequate radar warning receivers. Most fighter aircraft have no infrared warning systems. However, it is clear to

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[56]Wall, Robert. "USAF Updates Plans for Future Air Wars." *Aviation Week & Space Technology*. January 29, 2001. For more information on the F-22 Raptor, see CRS Issue Brief IB87111.

[57]*NSWAC Threat Emitter Briefing*. Mr. Richard Gent & Mr. John Smith. January 18, 2001. Fallon NAS.

> adversaries that U.S. forces rely on the ability to achieve air dominance. Further, these adversaries have greater access than ever to anti-aircraft missile systems with advanced seeker technologies. While future aircraft are being designed with protection systems, we cannot afford to leave today's forces ill-equipped to face the threat. While data links and information from other sensors can contribute to a pilot's situation awareness, it is not clear this will be adequate for a pilot to avoid an unexpected threat.[58]

This difference of opinion remains unresolved.

The final near term issue for Congress is the EA AOA, which should conclude its study late in this calendar year. Many EA AOA participants have indicated that the study will probably not recommend a single solution to replacing the Prowler, but instead will recommend a menu of solutions that the different services can implement as they see fit. Such an approach may have merit because it affords flexibility. However, this approach can also risk falling prey to making recommendations based on the "least common denominator," and make not the best recommendation, but the one that all parties can agree on. Congress may wish to closely monitor this activity.

There is another set of issues pertaining to EW and SEAD that don't necessarily need to be addressed immediately; Yet because they are complex and multifaceted, their resolution may take considerable time and effort, and therefore they invite scrutiny.

The first issue pertains to persistent reports of DoD's fractionated EW efforts. It has been noted by several different bodies that DoD does not have a coherent approach to EW issues. GAO's January 3, 2001 report "Comprehensive Strategy Needed for Suppressing Enemy Air Defenses," notes that "Within the Department of Defense, no comprehensive, cross-service strategy for closing the gap between the services' suppression capabilities and needs exists -- and no coordinating entity has been tasked with preparing such a strategy."(p.3) The Department of Defense itself recognizes that its overall EW efforts are unsatisfactory. In March 2000, Under Secretary of Defense Jacques Gansler initiated a study of 18 different EW programs that proved disappointing. Gansler wanted to determine how OSD and the Services may have contributed to these disappointments and to identify what processes could be developed to improve on these results.[59] Congress may wish to consider how it could help DoD approach EW challenges from the more unified perspective its leadership appears to seek.

The second issue pertains to the continued organizational placement of EW under Information Operations (IO) in the Air Force bureaucracy. The chief recommendation of a group commissioned to independently study how to improve the Air Force's EW activities was that the Air Force should promote EW from its current position as a subset of information operations, and refocus it under new acquisition

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[58] 106th Congress. 2nd Session. U.S. Senate. Department of Defense Appropriations Bill, 2001. Report 106-298. S.2593. May 18, 2000. P. 96-97.

[59] Butler, Amy. OSD Polls Contractors on How to Improve EW Acquisition Strategies. *Defense Information and Electronics Report*. April 7, 2000.

and requirements offices charged with improving aircraft survivability.[60] Although the Air Force has made organizational changes designed to elevate EW issues within budget and acquisition debates, congressional EW advocates may wonder whether the booming cyberwarfare sphere will continue to overshadow EW needs in the Air Force requirements process.

The final issue pertains to expediting the transition of promising EW and SEAD programs to the warfighter; notably innovative network-based approaches that the GAO and others endorse. Programs such as the AT3 and Network Centric Collaborative Targeting must overcome technological challenges and affordability constraints to become a reality. What can be even more challenging, however, is overcoming the acquisition system. Programs like AT3 exploit many different technologies and platforms such as aircraft, UAVs, communications links, radar warning receivers, GPS/INS systems, precision clocks, and digital terrain maps. There is no single Special Project Office, acquisition authority or end user of these systems, which makes guiding the program through the acquisition cycle difficult. Officials who work on the AT3 programs have described the difficulty they face trying to transition this program to the warfighter. As DoD increasingly moves toward "network centric"[61] approaches to warfighting, it may increasingly find that the acquisition system is not optimized for these types of programs. Congress may wish to consider how it can help DoD to pursue such innovative approaches to EW and SEAD.

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[60] USAF EW Management Process Study. October 1, 1999. Butler, Amy. Electronic Warfare to Remain Under Info Ops Umbrella, Official Says. *Inside the Air Force*. September 22, 2000.

[61] For a discussion of "network-centric warfare" see CRS Report RS20557, *Navy network-centric warfare concept: key programs and issues for Congress*.

Appendix 1: Acronyms and Abbreviations

AAA	Anti Aircraft Artillery
AAM	Air-to-Air Missile
AARGM	Advanced Anti-Radiation Guided Munition
ACC	Air Combat Command
ACTD	Advanced Concept Technology Demonstration
AEF	Aerospace Expeditionary Force
ANG	Air National Guard
AOA	Analysis of Alternatives
ARH	Active Radar Homing
ASPJ	Airborne Self Protection Jammer
ASTE	Advanced Strategic and Tactical Expendable
AT3	Advanced Tactical Targeting Technology
ATD	Advanced Technology Demonstration
ATP	Advanced Targeting Pod
BDA	Battle Damage Assessment
CAS	Close Air support
CMWS	Common Missile Warning System
CONOP	Concept of Operation
DARPA	Defense Advanced Research Projects Agency
DEAD	Destruction of Enemy Air Defenses
DoD	Department of Defense
EA	Electronic Attack
ECM	Electronic Countermeasures
EMD	Engineering Manufacturing and Development
EO	Electro Optical
EW	Electronic Warfare
FME	Foreign Military Equipment
FRY	Federal Republic of Yugoslavia
GAO	General Accounting Office
HARM	High Speed Anti-Radiation Missile
HTS	HARM Targeting System
IDECM	Integrated Defensive Electronic Countermeasures
ICAP III	Improved Capability III
IO	Information Operations
IOC	Initial Operating Capability
IR	Infra Red
ITALD	Improved Air Launched Decoy
JDAM	Joint Direct Attack Munition
JSOW	Joint Stand Off Weapon
LAIRCM	Large Aircraft Infra Red Countermeasures
LIFE	Laser Infra Red Flyout Experiment
LO	Low Observable
MALD	Miniature Air Launched Decoy
MMW	Millimeter Wave
NRO	National Reconnaissance Office
NVD	Night Vision Device
OAG	Operational Advisory Group
O&M	Operations and Maintenance
OSD	Office of the Secretary of Defense
PGM	Precision Guided Munition
PLAID	Precision Location and Identification
QDR	Quadrennial Defense Review
RDT&E	Research Development Test and Evaluation
RFCM	Radio Frequency Countermeasure
RSTA	Reconnaissance, Surveillance and Target Acquisition
RWR	Radar Warning Receiver
SAM	Surface to Air Missile
SAS	Signature Augmentation System
SEAD	Suppression of Enemy Defenses
UAV	Unmanned Air Vehicle

Appendix 2: FY2001 Appropriations for Select EW and SEAD Programs

(In thousands of Dollars)

Program	Request	Approp Conf.	Details
RDT&E USN EW Technology	26,043	26,043	
Advanced EW Tech	17,583	17,583	
EW Development	97,281	134,781	+8,500 Spray cooling technology for ICAPIII +3,000 Location of GPS jammers +23,000 EA-6B Link-16 connectivity +3,000 IDECM
EW Readiness support	9,924	9,924	
HARM Improvement	21,355	41,355	+15,000 AARGM +5,000 Quick Bolt ACTD
RDT&E - USAF Electronic Combat Technology	25,882	26,882	
EW Development	58,198	53,098	-19,800 AF withdrawal from CMWS +1,200 MALD +10,000 PLAID for ALR-69 +3,500 Survivability enhancements
F-15E Squadrons	61,260	68,860	+7,600 BOL IR
Procurement- USN EA-6B	203,102	189,302	-16,800 ICAP III Training System +3,000 EA-6B Ready Room Mission Rehearsal System
F/A-18 Hornet	2,818,553	2,775,953	-29,600 Premature IDECM RFCM Production Quantities
F-14 Series	30,481	31,481	+1,000 RWR antenna replacement and systems enhancement
Common ECM Equip	41,889	41,889	
Drones & Decoys	0	15,000	ITALD
Air Expendable Countermeasures	39,293	45,793	+6,500 MJU-52/B IR expendable countermeasures
Procurement - USAF F-16 C/D	0	122,000	Four Block 50/52 aircraft
B-52	8,425	42,525	+9,000 Electronic countermeasures and situational awareness
Advanced Target. Pod	34,921	34,921	
F-15	256,247	322,197	+26,400 BOL IR for ANG -10,450 ALQ-135 Delays and Problem